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The Air & the Pathogen - L P Smith

The fact that the air, its properties, processes and contents, plays a significant role in the spread of disease is easy to accept in principle. The difficulties arise when a degree of precision is sought, whether in detail, or more simply, in order of magnitude.

In an attempt at clarification, the influence of the air can be considered under three main headings. Firstly comes the possibility of a critical set of meteorological circumstances. If, in the chain of events which lead to the outbreak of a disease or the occurrence of a noxious pest, there is one link in the chain which is weather-sensitive, then the identification and specification of this link may be the effective dominating factor in solving the problem; the explanation may involve a requirement of location, as for example, the existence or absence of the intermediate snail host of the liver-fluke parasite, which depends on the weather-induced condition of the grass; it may involve a requirement of timing, as in the case of the soil temperature which determines the hatch of nemetoids, which may or may not coincide with the time when lambs begin to eat the grass. As will be seen later, this requirement of coincidence, either in place or time, may play a more important role than hitherto has been realized.

Secondly, the nature of the surrounding air and the strain it produces on a heat or energy balance or on a water balance, may result in a situation where a plant or animal (including the human animal) is pre-disposed to infection. It could be argued that the past or current weather has helped to create a condition which renders a subject less able to resist infection. Examples of this environmental stress occur often in the case of over-wintering farm stock, especially when they are pregnant. The effect may be direct, as in the case of excessive cold, wind or wetness; it may be indirect in that the inclement weather has prevented the animal from spending adequate grazing time and hence it may be undernourished; it may be even more indirect still, when inadequate natural food is replaced by supplementary feed which itself is of poor quality (due to previous unsuitable weather) such as bad or contaminated hay. The possible effect of pre-conditioning weather on human beings is less easy to specify, especially when the results may be both physiological and psychological, but it is not an effect which can be convincingly ignored. As an extreme case, a continually underfed population is likely to be far more susceptible to an epidemic, whether it be the Black Death or influenza.

Thirdly comes the category of the aerial transmission of pathogens, which is part of the wide field of aerobiology, and which contains such a large variety of half-understood factors, both pathological and meteorological, that it is not surprising that considerable difficulty is encountered in making firm progress and arriving at justifiable conclusions. Although each complicated part of the process can be investigated in detail, with varying degrees of success, no full comprehension can be reached without consideration of the whole sequence of events.

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The sequence can be regarded as starting with the physical conditions which determine the preparation of the pathogen to the state where incubation is complete or where sporulation can commence. Then follows the process which introduces the pathogen into the surrounding environment, either air or water; subsequently the movement of the transmission medium defines the track followed by the pathogen and the prevailing conditions determine its length of life and continued viability. Physical processes control its dispersion, both vertically and horizontally, and finally its deposition. The last controlling feature of all is the nature of the conditions under which subsequent infection can take place.

It can therefore be seen that for an efficient airborne epidemic a large number of controlling factors have to be satisfied in time and place. The degree of essential coincidence which is needed can now begin to be appreciated. Each stage in the process is not impossible, or even infrequent in occurrence, but it is the absence of any breakdown in the chain which ensures effective spread. This stipulation, in effect, means that this three-fold analysis of aerial effects has returned to its starting-point, because the critical weather conditions are the sensitive portion of the chain of events.

To investigate the problem, or any part of it, a research worker needs, besides imagination and intelligence, a deep appreciation of the facts or latest acceptable theories of pathological and meteorological processes, and most of all, a supply of reliable data. Meteorological data is relatively easy to acquire; it is recorded over dense networks, is of a homogeneous standard and, provided its limitations are understood,is of immense potential use. This does not imply that it never contains errors; such errors can occur from an inaccurate instrument, from a lapse by the observer, from an unrecognized effect of observational exposure, or from inadequate sampling. Furthermore, extrapolation into the future, with the assumption that past climate is reliably indicative of future weather, can introduce errors of deduction, which cannot be eliminated but which must be comprehended in terms of orders of magnitude. The least available type of meteorological data is that which involves indoor climates, whether of men or animals, which is at times a severe limitation in disease problems.

It is probably true to say that pest and disease data are not available on anything like a comparable scale or of equivalent quality. Apart from outstanding exceptions, there is an absence of complete or homogeneous assessments over long periods of time. This does not mean that existing data are unusable but merely that they have to be handled with care and with full realization of their possible degrees of uncertainty. The almost inevitable absence of sub-clinical data is a handicap which must be accepted, but not ignored.

Progress in understanding in a subject involving two or more sciences, each of which is complex, imperfectly understood and inadequately documented cannot be easy, but nevertheless encouraging results have been obtained, especially in recent years, and especially in countries such as the United Kingdom where circumstances have facilitated collaboration between research workers of different sciences. The day of the polymath is wellnigh over; demarkation disputes can be left to the small-minded; inter-disciplinary work must no longer merely be an empty phrase in an official report.

There are many ways in which such work can be pursued. Again, it is convenient to think in terms of three main avenues of approach. Firstly, the scale can be

a wide one, a type of macro-analysis in which the meteorological climate can be compared with the disease incidence on a large time and distance scale. Several useful concepts can arise in this manner, as for example in the field of tropical diseases, but it is difficult to make an analysis in depth by this method. It can provide a working answer, but rarely a complete one.

The complete answer must rely on work on a micro-scale, and fundamental work of this type, usually under laboratory conditions, is clearly essential for any arrival at the full truth of any weather-disease relationship. However essential this may be, there is no gainsaying the fact that it takes time, and furthermore it demands an unusual degree of personal ability, considerable facilities of opportunity and supporting finance, and not least, a degree of good fortune. Research, even by the best people under the best circumstances, can be dishearteningly unrewarding - meanwhile the problem persists.

There remains the operation on what can be called the meso-scale, dealing with limited data and arriving at interim answers, possibly in a semi-empirical manner. Full empiricism is to be avoided at all costs, especially when dealing with meteorological data, for mathematical coincidences without supporting scientific logic are an utterly inadequate basis for practical decisions. It is true that they may be accepted and put to use when nothing else is available, but it is only when a relationship begins to be understood that any confidence can be placed on it. Work on this scale can provide helpful indications of future thought and future action; its tentative conclusions can be tested on the macro and micro scales, but most of all it can have an immediate effect on current practices. A recent Technical Note (No 113) of the World Meteorological Organization entitled "Weather & Animal Diseases" gave examples of over a score of diseases which had been tackled in this way. In no case was a full solution reached, but in each investigation something new had been learnt regarding the effect of weather on the incidence and intensity of the disease in question.

In conclusion it is interesting to comment on common factors which seem to occur throughout the differing subjects of plant, animal and human disease. Reference has been made earlier to the importance of a coincidence of suitable conditions in place and time. It seems possible that, for epidemic conditions, this theory of coincidence should be taken a step further.

In more than one case there has been more than a suggestion that for a rapid build-up of any disease or pest, it is necessary that the suitable air conditions should occur twice, at an interval determined by the incubation period of the pathogen. If this is true it would not only explain why certain epidemics occur, but also would explain why they do not occur more often.

With such a proviso, we appear at last to be attaining a correct sense of proportion, both in time and space. The subject is a fascinating one; it is difficult but not impossible; the consequences of even limited success are beyond monetary assessment.

Any comments or suggestions on this paper should be referred to the author.

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